HydroViz: A Web-based Tool (or Courseware) for Supporting Active Learning in Engineering Hydrology Courses

http://hydroviz.cilat.org/

INSTRUCTOR'S GUIDE

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Introduction

The overall objective underlying the development of the HydroViz tool is to support active learning in the field of Engineering Hydrology. The development of HydroViz is informed by recent advances in hydrologic data, numerical simulations, visualization and web-based technologies. Through the use of this tool, HydroViz assist instructors in hydrology and water resources engineering courses by embedding fundamental hydrologic concepts and methodologies, into real-world experiences in a mid-size hydrologic basin (watershed). These experiences are delivered to students using web-based geospatial visualization technologies. HydroViz is composed of 13 learning modules incorporated into the web-based tool. Each module is self-contained, with instructions and technical questions embedded within the same screens that show the watershed and its visual displays. The modules can be introduced at different times during a single course, and some can be selectively used across different classes. While the HydroViz learning modules are developed for a specific watershed in south Louisiana, the contents of these modules cover fundamental hydrologic concepts and problems that are applicable to any other hydrologic sites.

Learning Modules in HydroViz

To facilitate the introduction of HydroViz in classrooms, and to fulfil its learning objectives, a total of 13 educational modules have been designed and embedded into HydroViz (Table 1). The modules range from basic activities (e.g., exploring watershed characteristics) to advanced analysis of field data and model simulations. Each module is self-contained and all instructions, guidance and technical questions are embedded within the same screens that show the watershed and its visual displays. These modules were designed using an actual rainfall event, Tropical Storm Matthew, which swept across south Louisiana for several days (October 7-10, 2004). Table 1 provides a list of these modules; the reader is referred to the HydroViz web tool (http://hydroviz.cilat.org/hydro) for a full description of each module and the student activities embedded into it:

Table 1: Summary of HydroViz learning modules (see http://hydroviz.cilat.org/hydro for details)

Module	Title	Brief Description
Module 1	Getting Acquainted with the Watershed	Introductory session to familiarize students with the watershed, its geographical/physical characteristics.
Module 2	Exploring Land-Use Land-Cover (LULC) Coverage Map	Students identify how many LULC classes exist in the watershed, identify which LULC class is dominant, assess main changes between recent/historical LULC
Module 3	Exploring Soil Coverage	Students use two soil-type layers to perform analysis on soil characteristics and estimate basic properties that control watershed response (e.g., hydraulic conductivity, porosity)
Module 4	Exploring Land Elevation	Students examine the watershed topography and drainage patterns, examine differences between different resolutions (1, 1/3, and 1/9 arc-second)
Module 5	Exploring Field Equipment	Students explore different hydro-meteorological sensors; activate links that provide description and animations on their operational mechanism; and download and analyze sample data
Module 6	Working with a Real Rainfall Storm	Students work with Tropical Storm Matthew that passed

Module 7	Analysis of Rainfall Measurements during Storm Mathew	over the watershed on October 7-10 of 2004; read news articles describing the storm impact; compare satellite images (prior and post-storm) and identify flooded areas; download and analyze in-situ rainfall data during the storm
Module 8	Measuring Rainfall Using Remote Sensing Techniques	Students explore rainfall estimates from satellites and radars during tropical storm Matthew; perform quantitative and graphical analysis to compare satellite and radar estimates versus ground rain gauges.
Module 9	Analysis of Streamflow Observations due to Storm Mathew	Students examine streamflow observations during Storm Mathew; generate time-series plots of streamflow data and corresponding rainfall; estimate runoff peaks, time-to-peak and total runoff volume; runoff-rainfall ratios.
Module 10	Runoff Analysis using Curve Number	Students apply the Curve Number (CN) method to estimate runoff depth during Storm Matthew; analyze effect of land-use scenarios and antecedent moisture conditions; apply TR55 method to estimate runoff depths under different distribution of impervious areas.
Module 11	TR55 Graphical Method	
Module 12	Setting up a Hydrologic Model	HydroViz introduces students to different steps necessary for building a distributed hydrologic model
Module 13	Hydrologic Model Simulations	Students evaluate results on model calibration and compare model-predicted versus observed hydrographs; visualize spatial fields of model simulations on different rainfall-runoff processes

Learning Objectives of HydroViz & Linkage to ABET Outcomes

The following is a summary of the main learning objectives of the HydroViz tool. Table 2 lists in which HydroViz modules the learning objectives are covered. Linkages to specific ABET outcomes are also provided in Table 1.

I. Identify and describe basic watershed characteristics, including watershed divide, outlet, area, drainage patterns, and sub-watersheds
II. Identify, describe and analyze current and historical land-use and land-cover patterns in a watershed
III. Identify, describe and analyze soil spatial coverage and types in a watershed and their main physical characteristics
IV. Identify and characterize differences in soil types and land-use coverage acquired from different national data sources available to practicing hydrologists
V. Identify and describe watershed topographic features and analyze the effect of spatial resolution of topographic datasets commonly available to practicing hydrologists
VI. Identify main hydrological and meteorological instruments and describe their functioning mechanisms and sampling characteristics
VII. Analyze real-world rainfall observations during an actual storm including time-series plots; calculations of rainfall depths, rates and total storm accumulations; and analysis and of spatial rainfall variability
VIII. Describe main techniques of remote sensing monitoring of rainfall storms
IX. Perform statistical analysis to characterize overall characteristics of uncertainty in remote-sensing rainfall information compared to ground observations

X. Analyze runoff measurements and calculate runoff peak, time-to-peak, total runoff depth, total runoff volume and runoff-rainfall ratio
XI. Solve problems on implementing the Curve Number method for rainfall-runoff calculations
XII. Solve problems on implementing the TR-55 method for rainfall-runoff calculations
XIII. Describe main steps in designing and setting up physically-based spatially-distributed hydrologic computer simulation models
XIV. Describe how model parameters can be linked to physical properties of the watershed
XV. Perform statistical analysis to characterize accuracy of hydrologic simulation models under calibration and validation experimental tests.

Table 2: List of HydroViz learning objectives and their linkage to HydroViz online modules and ABET outcomes

Learning Objective	HydroViz Module	ABET Outcome
I. Identify and describe basic watershed characteristics, including watershed divide, outlet, area, drainage patterns, and sub-watersheds	Module 1	*(b), (l)*
II. Identify, describe and analyze current and historical land-use and land-cover patterns in a watershed	Module 2	*(b), (l)*
III. Identify, describe and analyze soil spatial coverage and types in a watershed and main physical characteristics	Module 3	*(b), (l)*
IV. Identify differences in soil types and land-use coverage acquired from different national data sources available to practicing hydrologists	Module 2 & 3	*(b), (l)*
V. Identify and describe watershed topographic features and analyze effect of spatial resolution of topographic datasets commonly available to practicing hydrologists	Module 4	*(b), (l)*
VI. Identify main hydrological and meteorological instruments and describe their functioning mechanisms and sampling characteristics	Module 5	*(k)*
VII. Analyze real-world rainfall observations during an actual storm (time-series plots; calculations of rainfall depths, rates and total storm accumulations; and analysis of spatial rainfall variability)	Module 6	*(b)*
VIII. Describe main purposes techniques of remote-sensing methods for monitoring rainfall storms	Module 8	*(k)*
IX. Perform statistical analysis to characterize overall characteristics of uncertainty in remote-sensing rainfall information compared to ground observations	Module 8	*(b), (l)*
X. Analyze runoff measurements and calculate runoff peak, time-to-peak, total runoff depth, total runoff volume and runoff-rainfall ratio	Module 9	*(b), (e), (l)*
XI. Solve problems on implementing the Curve Number method for rainfall-runoff calculations and effect of land-use changes on flooding	Module 10	*(e), (i), (l)*
XII. Solve problems on implementing the TR-55 method for rainfall-runoff calculations	Module 11	*(e), (l)*
XIII. Describe main steps in designing and setting up physically-based spatially-distributed hydrologic computer simulation models	Module 12	*(k)*
XIV. Describe how model parameters can be linked to watershed physical properties	Module 12	*(a), (k)*
XV. Perform statistical analysis to characterize accuracy of hydrologic simulation models under calibration and validation experimental tests.	Module 13	*(a), (b), (e)*

Which Courses HydroViz Supports and how HydroViz can be used in the Classroom

HydroViz is primarily designed for in junior/senior level courses within Civil and Environmental Engineering curriculum. Selected modules can be used in freshmen-level civil engineering courses. Advanced modules in HydroViz can also be used in first-semester graduate courses. The following is a brief description of when and how HydroViz can be used at different stages in the curriculum. Table (3) provides a list of civil engineering courses, and which topics/chapters in each course, that can use HydroViz.

Use of HydroViz in Junior/Senior Hydrology civil engineering courses: The educational modules can be introduced to the students at different stages within a single course, where each module can serve as an educational companion to the technical subject covered by the instructor (Table 2). For example, in an Engineering Hydrology class, the HydroViz module on "Exploring Field Equipment" can be assigned to the students while the instructor is covering a textbook chapter that deals with hydrologic measurements. Similarly, the instructor can use the first four modules that focus on watershed physiographical characteristics to support students learning of basic watershed concepts beyond pure textbook coverage of such topics. HydroViz modules on runoff analysis and Curve-Number calculations can be used as real-world example applications to supplement homework problems typically assigned for hypothetical watershed sites. Advanced modules in HydroViz on remote-sensing observations and numerical model simulations can be used in under-graduate Hydrology courses, but should be treated as optional.

Use of HydroViz in first-year graduate courses: Advanced modules in HydroViz on remote-sensing observations and numerical model simulations are best suited for firs-year courses in graduate programs that focus on water resources and hydrology. The entire suite of modules in HydroViz can be used in a graduate-level course for students to refresh and review their prior knowledge on the subject matter and reemphasize concepts that may have not been covered in their undergraduate curriculum.

Use of HydroViz in freshmen civil engineering courses: While HydroViz is primarily designed to be used in junior/senior level courses, it can also be used in freshmen introductory-level courses to expose new civil engineering students to basic watershed and hydrologic concepts, variables, rainfall-runoff processes, spatial geographic data, and field measurements and sensors. The instructor can select a limited set of modules to use within the freshmen-level classes. The usage of hands-on software such as HydroViz at early stages within the curriculum can be rather inspiring for young students who are motivated by real-world and interactive applications. To facilitate the usage of HydroViz in such classes, advanced questions and topics within the HydroViz educational modules have been tagged with an optional flag, but are still made accessible for all students who have scientific curiosity to experiment with such advanced topics.

Table 3: List of Engineering courses and subjects/chapters that can be supported by HydroViz (UG: Undergraduate; G: Graduate)

Module	Title	Target Course Level	Course Subject/Chapter
Module 1	Getting Acquainted with the Watershed	**UG** (Engineering Hydrology / Water Resources) **UG** (Intro to Civil Engineering)	Watershed Concepts
Module 2	Exploring Land-Use Land-Cover (LULC) Coverage Map	**UG** (Engineering Hydrology / Water Resources) **UG** (Intro to Civil Engineering)	Watershed characteristics/ Hydrologic Processes
Module 3	Exploring Soil Coverage	**UG** (Engineering Hydrology / Water Resources) **UG** (Intro to Civil Engineering)	Watershed characteristics/ Hydrologic Processes
Module 4	Exploring Land Elevation	**UG** (Engineering Hydrology / Water Resources) **UG** (Intro to Civil Engineering)	Watershed characteristics/ Hydrologic Processes
Module 5	Exploring Field Equipment	**UG** (Engineering Hydrology / Water Resources) **UG** (Intro to Civil Engineering)	Hydrologic Measurements and Instrumentation
Module 6	Working with a Real Rainfall Storm	**UG** (Engineering Hydrology / Water Resources)	Hydrologic Processes
Module 7	Analysis of Rainfall Measurements during Storm Mathew	**UG** (Engineering Hydrology / Water Resources)	Hydrologic Analysis
Module 8	Measuring Rainfall Using Remote Sensing	**G** (Advanced Hydrology / Remote Sensing)	Remote Sensing of Rainfall
Module 9	Analysis of Streamflow Observations due to Storm Mathew	**UG** (Engineering Hydrology / Water Resources)	Hydrologic Analysis / Surface Runoff
Module 10	Runoff Analysis using Curve Number	**UG** (Engineering Hydrology / Water Resources)	Surface Runoff / Hydrologic Design / Hydrology of small Catchments
Module 11	TR55 Graphical Method	**UG** (Engineering Hydrology / Water Resources)	Hydrologic Design / Hydrology of small Catchments
Module 12	Setting up a Hydrologic Model	**G** (Advanced Hydrology / Hydrology Modeling)	Introduction to Hydrologic Modeling
Module 13	Hydrologic Model Simulations	**G** (Advanced Hydrology / Hydrology Modeling)	Introduction to Hydrologic Modeling

Timeline of using HydroViz

The 13 web-based learning modules in HydroViz can be introduced to the students at different stages within a single course. Each module can serve as an educational companion to the technical subject or textbook chapter covered by the instructor. All or some of the modules can be used in typical Engineering Hydrology and Water Resources Courses. It is recommended that the first four modules should always be covered. Instructors can choose from the other modules based on their course syllabus.

Students' Assignments in HydroViz

To facilitate the classroom usage of HydroViz, each educational module has been designed as a set of incremental activities that the students need to perform. Based on such activities, a set of questions are embedded within the module and students are asked to record their activities and answers to such questions and type them in a WORD file to be submitted to the instructor. These are considered as students' assignments which need to be submitted by each student after finishing the assigned module(s). A template file with the embedded questions is provided for each module's assignment to facilitate students' work with HydroViz and provide a standard mechanism for collecting their answers and feedback.

Prior Guidance to Students

Before using HydroViz, the Instructor needs to provide the students with a brief introduction on HydroViz, its objectives and overall features. Such information is provided on the main tabs of the HydroViz project website (http://hydroviz.cilat.org/). A short tutorial video on HydroViz is provided with this Instructor Guide and is available online. The Instructor should play this short tutorial at the beginning of the first class session where HydroViz will be used. The video provides basic information on the structure of the HydroViz tool, its learning modules, spatial navigation, and use of layers and drawing/measuring tools embedded within the software. The Instructor should go over how the students can download the file templates needed for completing the HydroViz assignments. Unless the full suite of the 13 HydroViz modules are assigned, the Instructor needs to indicate to the students which modules they will be working on. Navigation from on module to another need not necessarily be done in sequence (i.e., students can go directly to a later Module and then choose to come back to an earlier one). While the modules are self-explanatory and self-sufficient in terms of guidance and instructions, the Instructor may need to walk the students through one of the modules (e.g., Module 1) as an illustrative example.

Software Requirement

HydroViz can run on any platform with access to Internet. Users may need to install a freeware Google-Earth web-browser Plugin available from (http://www.google.com/earth/explore/products/plugin.html)

Pre-requisites of software proficiency

Basic knowledge on how to use the Internet, and basic knowledge on the use of word processing and spreadsheet software (e.g., WORD and EXCEL)